Appendix 4-A (Performance Chapter)
Overall Performance Demonstration Methodology

I. PERFORMANCE TESTING OVERVIEW

A. Goal

The objective of the performance demonstration is to collect specific information from flexographic printing facilities about the print quality, costs, and environmental and human health risks associated with different types of ink systems, as they are printed on different types of film substrates. This data will be incorporated into the overall project report, called the Cleaner Technologies Substitutes Assessment (CTSA).

B. Methodology Overview

The DfE Flexography Project will demonstrate the performance of three ink systems (solvent, water-based, and UV) on three different film substrates (oriented polypropylene, low-density polyethylene, and polyethylene/ethyl vinyl acetate). Each substrate/ink combination will be run on a wide web press in at least two separate volunteer printing facilities. During each demonstration, the press will be run at production speeds (300-500 ft/min) for approximately two hours to produce up to 60,000 feet of printed product. The 20" x 16" image will include both process tone printing in various gradations and two-color line printing. During and following the demonstration run, laboratory tests will be conducted to determine how well each ink system performed the desired task. To allow a comparison of the different ink systems, data will be collected on performance, cost, human health and environmental risks, and energy and natural resources use for each ink system.

The materials used in the demonstrations are expected to be donated to the Project by industry participants. Ink manufacturers will be asked to submit the required quantity of ink to the Project. Substrate manufacturers will be asked to submit the required length of film substrate. And, finally, printers will be donating their press time to the DfE Project.

Flexographic printing experts from Western Michigan University's (WMU) Department of Paper and Printing Science and Engineering will oversee the on-site demonstrations to ensure that the performance demonstration methodology outlined in this documented is followed consistently at all demonstration sites. Following the demonstrations, they will conduct laboratory tests to evaluate the print quality of the printed substrate.

Project Participants

This performance demonstration methodology was developed by a group of volunteers from the flexography industry with input from the DfE Flexography Project partners including representatives of: California Film Extruders and Converters Association (CFECA), Film and Bag Federation (FBF, previously the Plastic Bag Association), Flexible Packaging Association (FPA), Flexographic Technical Association (FTA), Industrial Technology Institute (ITI), National Association of Printing Ink Manufacturers (NAPIM), RadTech International, National Institute of Standards and Technology (NIST), Tag and Label Manufacturers Institute (TLMI), University of Tennessee (UT), and Western Michigan University (WMU).

II. INFORMATION TO BE COLLECTED

A. Performance Information

Performance data will provide printers with information on the effectiveness of the different ink systems evaluated under comparable conditions. While the DfE Flexography Project has made every attempt to ensure that these demonstrations will be run under consistent conditions, they are being conducted in actual printing facilities nationwide. As no two printing facilities are identical, it should be noted that the performance demonstrations are not rigorous scientific investigations. Instead, they couple the more qualitative performance evaluations with quantitative laboratory testing results. This combination of performance information in conjunction with the cost and risk data, will allow printers to compare the trade-offs between the various ink systems.

B. Costing Information

A cost analysis for each ink system will be conducted using supplier data, industry statistics, and information from the performance demonstration. Data collected during the performance demonstration that will be used in the cost analysis includes: amount of ink used; labor requirements for makeready, demonstration run, and clean-up; materials used; waste generated; energy and natural resources used; waste management requirements; and clean-up products used.

C. Environmental and Human Health Risk Information

A third component of this project is a technical evaluation of the human health and environmental concerns associated with each ink system. While much of this analysis will be based on the chemical formulation of each ink system (to be submitted by the ink suppliers), information on the associated occupational exposures will be collected through the performance demonstration.

III. PRODUCTS TO BE DEMONSTRATED

A. Ink Specifications

1. Eligibility of Inks

The performance demonstration is open to any commercially available flexographic ink system. Ink manufacturers who would like to submit their ink as a candidate for the demonstrations will be asked to supply a volume of their ink needed for the initial laboratory tests.

2. Number of Ink Systems

Inks are needed for printing on three substrates: Oriented Polypropylene (OPP), Low-density polyethylene (LDPE), and Polyethylene/Ethyl Vinyl Acetate (PE/EVA)). A detailed description of the substrates follows in section III.D. If each substrate requires a different ink system, a maximum of nine different ink systems will be needed.

Nomenclature is as follows:

	Ink System Name	Ink	Substrate
1.	S-OPP	Solvent	OPP
2.	W-OPP	Water	OPP
3.	UV-OPP	Ultra Violet Curable	OPP
4.	S-LDPE	Solvent	LDPE
5.	W-LDPE	Water	LDPE
6.	UV-LDPE	Ultra Violet Curable	LDPE
7.	S-PE/EVA	Solvent	PE/EVA
8.	W-PE/EVA	Water	PE/EVA
9.	UV-PE/EVA	Ultra Violet Curable	PE/EVA

3. Colors to be Demonstrated

The demonstration will include printing line colors and process colors, as identified in the Pantone Color Selector/Film Guide. For the OPP substrate, the film will be reverse printed and used as a laminate. The colors printed will be:

Line colors

White - Opacity target (48-50), to be used with the OPP and LDPE
Reflex Blue
354 Green

Process colors

Magenta (rubine red)
Cyan (phthalocyanine blue)

B. Initial Laboratory Testing

Within the three ink systems (solvent-based, water-based, and UV-curable), one product line may be selected for each of the three substrates (OPP, LPDE, PE/EVA), for a maximum of nine ink systems. If certain product lines can be used on more than one substrate type, fewer product lines will be required. If more than one product line within an ink system is submitted for the same substrate, the ink that most closely matches the ink currently used by the volunteer facility will be selected. Prior to sending inks to the field, WMU will test the inks in their Pilot Printing Plant as follows:

1. The ink suppliers will be asked to provide WMU with samples of white, cyan and green inks for the initial laboratory testing.

2. At the WMU pilot plant, each ink sample will be mixed for color and viscosity at the press to the manufacturer's specification, using solvents/additives provided by the ink supplier.

3. One printing station will be used for the tests. A 440 line anilox will be used to print the cyan and green inks. A 220 line anilox will be used for printing the white inks.

4. One test plate will be used for evaluation of the cyan and green inks.

5. Non-UV curable inks will be assigned to either the solvent or water category, based on the chemical and volatile organic compound (VOC) content information on each ink's MSDS. If the press side VOC content of the water-based inks exceeds 25% of the volatile component (e.g., 75% water, 25% VOC), the ink will be classified as solvent-based.

6. Each ink will be printed on each type of substrate (OPP, LPDE, PE/EVA) at the maximum attainable press speed (up to 500 ft/min).

7. Once maximum attainable press speed is reached, total run time will not exceed 3 minutes.

8. A series of performance tests will be conducted to evaluate the quality of the printed samples.

C. Dry Run at WMU Pilot Plant

The inks selected for the field demonstrations will be "dry run" at the WMU Pilot Plant prior to sending them to the volunteer facilities. The purpose of this one hour dry run is to determine if any problems are likely to occur during a longer run. The dry run procedure will be:

1. Each substrate will be run with the selected ink using the following color combinations:

Solvent Inks (1 - 3 different inks)

Run 1	OPP	White + Green
Run 2	LDPE	White + Green
Run 3	PE/EVA	Green + Cyan

Water Inks (1 - 3 different inks)

Run 4	OPP	White + Green
Run 5	LDPE	White + Green
Run 6	PE/EVA	Green + Cyan

UV Inks (1 - 3 different inks)

Run 7	OPP	White + Green
Run 8	LDPE	White + Green
Run 9	PE/EVA	Green + Cyan

2. Each ink sample will be mixed for color and viscosity at the press to the manufacturer's specification, using solvents/additives supplied by the ink supplier.

3. Two printing stations will be used. A 440 line anilox will be used to print the cyan and green inks. A 220 line anilox will be used for printing the white inks.

4. The plates used in initial laboratory test run will also be used for the dry run.

5. Each ink will be printed on each type of substrate (OPP, LPDE, PE/EVA) at the maximum attainable press speed (up to 500 ft/min).

6. Once maximum attainable press speed is reached, total run time will be one hour.

7. During the dry run, exposure monitoring will be conducted in two testing zones — at the operator consol and the dryer exhaust stream. In each zone, testing will be conducted for two time periods: 0 to 15 minutes and 15 to 60 minutes.

8. During the dry run, data will be collected on energy used by the drying systems, corona treater, UV lamps, ink pumps, press, and emission control devices.

9. For each printed substrate, a select series of performance tests will be conducted.

D. Substrates Used in Testing

Each ink system will be run on three different film substrates. These substrates were selected by the Project Technical Committee to represent "typical" substrates used in flexography.

1. Substrate Types

It is expected that the film will be donated by film substrate manufacturers and sent directly to participating facilities. The three types of film that will be used are:

- **OPP (Oriented Polypropylene)** - *75 gauge - slip modified*
  Film to be reverse printed and used as a laminate. Typical products manufactured from this film are snack food bags and candy bar wrappers.
- **LDPE (Low-density polyethylene)** - *1.25 mil - medium slip - clear - 0.2 to 0.5 C.O.F. (ASTM D 1984)*
  Film to be surface printed. Typical products manufactured from this film are shopping bags and bread bags.
- **PE/EVA (Polyethylene/Ethyl Vinyl Acetate co-extruded film)** - *2.5 mil - white high slip - 0.2 C.O.F. (ASTM D 1984) - print PE side*
  Film to be surface printed. Typical products manufactured from this film are frozen food bags.

2. Substrate Quantities

For each substrate type, each of the three ink types will be printed during the initial laboratory tests and for two hours in at least two different facilities during field demonstrations. Total substrate quantities required are as follows:

	at WMU	at TEST FACILITIES							
Ink Type	Laboratory Testing	+	Make-ready	+	Run Time x Press Speed = Run Footage	Per Facility Sub-Total	x 2	Facilities =	Total
Solvent-based	60,000 ft.	+	15,000 ft.	+	2 hrs. x 500 ft/min = 60,000 ft.	75,000 ft.	x	2 facilities = 150,000 ft.	210,000 ft.
Water-based	60,000 ft.	+	15,000 ft.	+	2 hrs. x 500 ft/min = 60,000 ft.	75,000 ft.	x	2 facilities = 150,000 ft.	210,000 ft.
UV-curable	60,000 ft.	+	15,000 ft.	+	2 hrs. x 500 ft/min = 60,000 ft.	75,000 ft.	x	2 facilities = 150,000 ft.	210,000 ft.
Total footage*	180,000 ft.	+	45,000 ft.	+	180,000 ft. =	225,000 ft.	x	2 facilities = 450,000 ft.	**630,000 ft.**

*needed for each substrate

3. Other Substrate-related Requirements

- All films are to be treated on press with corona treatment to a specified dyne level that meets the specific ink manufacturer's specification. The exact treatment level will vary for the different ink systems (solvent, water, UV) and will be recommended by the printer. Target dyne levels may range from 38-45 dynes/cm^2.
- Core specifications are press reel dependent and will be determined after the list of participating facilities is finalized.
- All demonstrations will be run on wide web presses. The target web width is 24".
- The identification number and the date of manufacture for the films will be recorded during the performance demonstration. Substrate preferably will be manufactured no later than 6 months prior to the press run.

E. Image and Plates

Each demonstration facility will receive a new set of plates to minimize the variables associated with plate wear. The image will include both process tone printing in various gradations and two-color line printing, as described below:

1. Image

The same test image will be used for all demonstrations. Image width will be 20" and length will be 16". The image is designed so all required tests can be conducted on the printed substrate. A black and white, size-reduced copy of the image used can be found in Appendix 4-D.

2. Plate Manufacturing - recommended[1]

The plates will be manufactured according to the following specifications:

- All plates will be manufactured in the same lot by the same manufacturer to maximize consistency.
- Plates will all be made of the same photopolymer material.
- Plate gauge is press dependent and will be finalized when the list of participating facilities is finalized.
- Plate cylinder circumference will be 16" to 18" (single repeat). Circumference will be finalized when the list of facilities is finalized.

3. Plate Configuration

- OPP will be reverse printed. LDPE and PE/EVA will be surface printed.
- The image will be a combination of line and halftone as follows:

<u>Configuration 1: Magenta + Cyan</u>

- Two color combination to include process tones, trap and tone scales.
- 120 line screen.
- Tone to be multiple gradations of 3, 10, 15 , 20, 25, 35, 40, 50, 60, 70, 80, and 100 percent.
- Magenta + cyan to meet with 50% trap of tones and solids.

<u>Configuration 2: White Background with Reflex Blue and Green Overprinted</u>

- The image will emphasize large solid formation and trap.

F. Press Configuration

While the specific make and model of press used will vary from one participating facility to the next, the DfE Flexography Project partners have established some guidelines to maximize consistency in the type of press used. While the Project does not intend to exclude any printers who may be interested in participating, an effort to maintain consistency in the press type will provide more comparable data from the demonstrations. All press configuration parameters will be documented for each printing facility.

1. Press Configuration - recommended

- Central impression press.
- Six-color.
- Production speeds of 300 - 500 feet/minute or optimized for print quality.
- Wide web press with a target width of 24 inches.

[1] This is the recommended method for platemaking. However, if a participating facility has special requirements for their plates, the plates for that facility may be manufactured on-site, using the same image.

- Plate cylinder circumference of 16" to 18" (single repeat).
- Inking system with chambered doctor blade units.
- Target specifications for **anilox rolls**: *(note these are **target** values only)*
  - Process anilox rolls
    Screen count = 600 to 700 lines per inch (LPI)
    Volume = 1.5 billion cubic microns (BCM)
  - Line anilox rolls
    Screen count = 440 LPI
    Volume = 4 to 6 BCM
  - White
    Screen count = 150 LPI
    Volume = 6 to 8 BCM
    or
    Up to 15 BCM may be appropriate for UV applications.

2. Dryer configuration

- Temperature: substrate dependent; will be measured and recorded.
- Velocity: press dependent; will be measured and recorded.
- Web dwell: press dependent; will be measured and recorded.
- Balance: press dependent; will be measured and recorded.

IV. DEMONSTRATIONS

The observation team from WMU will oversee each of the demonstrations to insure that the methodology is followed. The team will also record all relevant data regarding the press, the substrate, the ink, energy use, and general information on the demonstration and the facility. To insure that consistent data are collected among participating facilities, the observation team will complete a set of data collection forms for each demonstration run. See Appendices 4-B and 4-C for blank copies of these forms. The DfE Flexography Project highly recommends that a representative of the ink manufacturer be on site during demonstration of the ink, if possible.

A. Pre-Makeready

Before ink and substrate impression starts, information will be recorded on the steps taken to prepare for the print run and on the operating conditions under which the demonstration will take place:

1. Record background information on:
   - ***Ink:*** ink system type, ink manufacturer name and ink name.
   - ***Plate:*** plate gauge, plate mounting method.
   - ***Press:*** manufacturer and model, press width, maximum web width, number of print units, distance between color stations, drum diameter, anilox roll configuration (type, lines per inch, volume, diameter, and condition), ink pumping system, type of doctor blade system, and a description of adjacent equipment running during the performance demonstration.

   - ***Drying System:*** make and model of each drying (or UV) unit, drying area of each of the interstation dryers (or UV lamps), dryer area of main tunnel dryer (or final UV-curing lamp), air flow capacity in cfm, and, if applicable, the make and model and location of chillers.
   - ***Energy Requirements:*** from the equipment nameplates or from facility maintenance

records, record the energy specifications for the drying systems (electrical or gas-fired dryers), corona treater, UV lamps, chillers, ink pumps, press, and emissions control devices.
- ***Substrate:*** identification number of the roll, date of manufacture, corona pre-treatment level.
- ***Waste Treatment:*** description of on-site waste treatment capabilities (including incineration), reliance on off-site waste treatment and disposal, annual or quarterly costs and volumes for the facilities waste disposal and treatment, an estimate of the percentage of these costs attributable to the facility's flexographic operations.
- ***History:*** the experience this facility and of the press operator assigned to help with the demonstration. Include the length of time the facility and this operator have been running this ink system and substrates, how frequently they run it, and the operator's opinion of the ink system and substrates being demonstrated.

2. Web the press.

3. Measure and record the surface tension on the operator side and on the gear side of the web following the procedure in Appendix 4-I.

4. Mount the printing plates.

5. Pre-align anilox cylinder to plate, and plate to impression cylinder.

6. For surface print runs, the desired sequence of colors is white, magenta, cyan, green blue. For reverse printing, the desired color sequence is magenta, cyan, green, blue, white. Record the print unit number for each color.

7. Add inks and pre-mix in sumps. Record the manufacturer name and number of each of the components added. Components may include ink, extender, solvent, and any other additives. Weigh each component and record the quantity used.

8. For each color, measure and record the viscosity of the ink using a #2 Zahn efflux cup. For UV inks, record the manufacturer's reported viscosity.

9. Record any observations or occurrences during the pre-makeready step (e.g., any problem with the ink, plates, or substrate that may influence the demonstration results).

B. Makeready

Prior to production, makeready activities (set-up operations to optimize image quality) will be performed. For the performance demonstration, collect information on the makeready activities:

1. Record the start time for makeready.

2. Record (or zero) the meter reading for the length of substrate printed.

3. Record the treat level before and after corona discharge treatment. Also record the corona treater power level.

4. Measure and record the surface tension on the operator side and on the gear side of the web

following the procedure described in Appendix 4-I.

5. Complete the alignment of the anilox cylinders to the plates, and of the plates to the impression cylinder.

6. Optimize the press speed. Record.

7. Optimize the ink viscosity and color by matching it to the Pantone color swatches. Weigh and record the quantity of any components added to the ink to optimize viscosity and color. Record the ink viscosity after each addition. Repeat for each color.

8. Optimize the dryer settings. For each interstation dryer and for the main tunnel, record the air temperature and velocity.

9. When the print and color quality are acceptable, record the time the makeready is complete.

10. Record the meter reading for substrate length printed during the makeready.

11. Record the quantity of substrate waste generated during makeready.

12. Following the test procedure specified in Appendix 4-E, measure and record the print density after acceptable color and print quality is achieved. If any additions are made to the ink, repeat the measurement and record the print density.

13. Perform the tape adhesiveness test on all colors. Record the results. If any adhesion failure occurs, record an estimate of the percentage of ink lifted from the substrate. A detailed description of the test procedure can be found in Appendix 4-E.

14. Visually inspect the printed image for the following qualities and record a qualitative assessment of each:

- Trap
- Blocking
- Dimensional stability
- Mottle

15. Record any other observations or occurrence during the makeready.

C. Demonstration Run

During the print run, information will be collected on any problems encountered and any changes made to maintain constant print quality.

1. Record the start time of the demonstration run and run for 2 hours. If a problem is encountered and the 2 hour run can not be completed, any run of 1 hour or longer will be considered complete with sufficient data for the evaluation of performance, costs and risk.

2. Record (or zero) the meter measuring substrate length printed.

3. Mark the substrate roll to indicate the end of the makeready printing.

4. Mark the roll every 30 minutes for post-run laboratory testing.

5. Using a reflection densitometer and following the test procedure specified in Appendix 4-E, measure the print density at the start of the run for each color. If any additions are made to the ink, repeat the measurement and record the print density.

6. Measure and record the ink viscosity for each color every 15 minutes. Record the quantity of any additions made to the ink.

7. Record the press speed.

8. Record the time the run is completed.

9. At the end of the run, record the meter reading for linear feet of substrate used.

10. Record the quantity of substrate waste generated during the demonstration run.

11. Record any other observations or occurrence during the demonstration run. Record any of the practices of the facility that may have affected the demonstration results (e.g., equipment malfunction, substrate problem).

12. Visually inspect the printed image for the following qualities and record a qualitative assessment of each:

- Trap
- Blocking
- Dimensional stability
- Mottle

13. Wrap and secure the printed roll.

14. For the OPP, which will be reverse printed and used as a laminate, the adhesive and the second substrate will be applied to approximately 200 feet of film taken from the middle of the print run. If the demonstration facility has the capability to laminate in-house, the substrate will be laminated on-site. The lamination equipment procedure, adhesive, and the second substrate used will be recorded. If the facility does not have lamination capabilities, the substrate will be sent off-site to a lamination facility. Once the volunteer facilities are finalized, every effort will be made to standardize the lamination materials and procedures used.

V. CLEAN-UP

After the print run is complete, record information on the steps taken and products used to clean the press in preparation for the next print job.

A. Clean-up Methods

Record the procedures used at each facility for clean-up. If the facility is unfamiliar with the clean-up procedures for the type of ink used in the demonstration, follow manufacturer's recommendations.

1. Record start time for clean-up.

2. Allow the excess ink to drain into an empty container. Squeegee any remaining ink from the pans into the same container. Weigh the excess ink and record.

3. Record the washing procedure for cleaning the ink pumps, ink rolls, ink and other components.

4. Record the time when cleaning is complete.

5. Record any procedures or occurrences that may influence clean-up time.

B. Clean-Up Chemicals

1. Record the manufacturer's name and the product name for all chemicals used. Make a copy of the MSDS for each product used during cleanup.

2. Record all clean-up steps where water was used.

3. Record the quantity of each chemical used for clean-up.

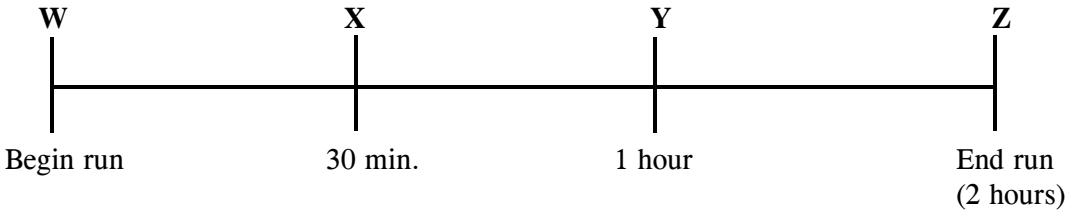
4. If clean-up products are reused or recycled, document the technique used and the percentage of product reclaimed or recycled.

VI. POST-RUN LABORATORY TESTS

After the demonstration run is complete, the roll of printed substrate should be wrapped and shipped immediately back to WMU. At the WMU laboratory, a series of tests will be performed to assess the print quality. These tests are listed in the table on the following page. While the tests checked off under "Makeready" and "Press" will be conducted visually during the demonstration, more quantitative testing will be conducted for the tests checked off under the "Laboratory" heading. The testing protocol for each of these can be found in Appendix 4-E.

A. Location of Samples

All tests will be repeated at four different position in the printed roll:



- All samples will be collected from each location (W, X, Y, Z).
- At each location (W, X, Y, Z) either 1 or 5 repeats will be taken, as indicated in the "**# of Samples**" column of the table.
- Test measurements will be conducted at 2 cross web points on each repeat.
- For the Coat Weight test, 50 images will be pulled and weighed at each of the testing time locations.

B. Colors to be Sampled

The "Colors" column of the table indicates the colors on which the results for this specified test will be recorded. "White +1" indicates that test results will be recorded for the white ink and one other color. In the case of PE/EVA printed substrate, only the results of the one color test will be recorded since white ink will not be printed on this white substrate. If this column is Not Applicable, as in the case of Coat Weight, "NA" is noted in the column.

C. Laboratory Tests List

	TEST METHOD	Initial Lab Test	Dry Run	Make-ready	Press	Lab	# of Samples	Colors
1-A	Adhesion/Flexible Pack.		X			X	5	white+1
1-B	Adhesive Lamination (laminate only)					X	5	NA
2	Adhesiveness -Tape		X	X	X		5	white+1
3	Extrusion Lamination (laminate only)					X	5	NA
4	Sutherland Rub (surface print only)	X	X			X	5	white+1
5	Block Resistance		X	X	X	X	5	white+1
6	Color L*a*b*	X	X			X	1	all
7	Density - Print	X	X	X	X	X	1	all
8	Image Analysis (quantitatively - dot structure)		X			X	1	all
9	Opacity (white only)	X	X			X	1	white
10	Gloss (Gardner 60°) (not for reverse print)		X			X	1	all
11	Mottle/Lay (Tobias tester)	X	X	X	X	X	1	all
12	Dimensional Stability		X	X	X	X	1	all
13	Coat Weight (dry lbs./ream)		X			X	50	NA
14	Coefficient of Friction (not reverse)		X		X	X	5	NA
15	Heat Resistance - Heat Seal (Sentinel - OPP only)					X	5	white+1
16	Ice Water Crinkle Resistance (PE & PE/EVA)		X			X	5	white+1
17	Odor		X			X	5	NA
18	Surface Tension - Film (dynes)		X	X	X		1	NA
19	Solvent Retention (MS)		X			X	5	all
20	UV- Uncured Residue		X				5	all
21	Trap	X	X		X	X	1	cyan+ magenta

NA= Not Applicable

Appendix 4-B (Performance Chapter)
Facility Background Questionnaire

BACKGROUND

Approximate total sales:	
Percent of sales from flexographic-printed products:	

Total flexographic output of facility (by weight, surface area, or linear feet):	

Type of product	Percent of total sales	Type of product	Percent of total sales
Flexible packaging	%	Folding cartons	%
Commercial printing	%	Gift wraps and papers	%
Corrugated containers	%	Newspapers	%
Tags and labels	%	Other:	%

Type of ink	Percent of total product sales
Solvent-based	%
Water-based	%
UV-curable	%

Type of substrate	Percent of total product sales
Film:	%
Film:	%
Film:	%
Other:	%

Production hours:			
Daily		Annually	
Average length of time of job run			
Average length of time of makeready			

ENVIRONMENTAL PERFORMANCE

Ink disposal/treatment method (please describe):

Annual ink waste treatment and disposal costs:

Substrate recycling (please describe):

Annual costs or savings for substrate recycling:

Solid/hazardous waste treatment and disposal (please describe):

Annual costs for solid/hazardous waste treatment and disposal:

COSTS

Bulbs for drying lamps, annual cost and annual quantity used:

Doctor blades, annual cost and annual quantity used:

Ink cleaning equipment price and year of purchase:

Ink cleaning supplies, annual cost:

Explosion protection measures cost:

Ventilation/air filtering equipment price and year of purchase:
Annual cost for filters, etc.:

CLEANING PROCEDURE

What is the cleaning procedure for removing ink after a run?

How are used rags handled (industrial laundry or disposal):

What employee protective gear is used when cleaning (circle all that apply):
eye shields gloves apron respirator

Is the total volume of cleaning solution captured?

If yes, how is the captured solution disposed of?

Is the total volume of cleaning solution reused?

If yes, how often is the solution reused?
Is it processed in any way prior to reuse?

Is the used cleaning solution discharged directly to the sewer?
Is it pretreated?

PROCESS HISTORY

If you are using water-based or UV ink to print on film substrates, when did you switch from solvent-based inks?

Why did you switch?

What changes were required to the equipment, the substrate, or your work practices to make this ink work?

What costs or savings are associated with the switch?

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Appendix 4-C (Performance Chapter)
Performance Demonstration Data Collection Form

I. Press Configuration

A. The press

Press manufacturer		Model	
Age of press		Typical production speed	
Press type *(circle)*	CI in-line stack	Maximum web width	(in)

B. Print units

Number of print units	
Distance between color stations	
Drum diameter	

C. Anilox

Print unit					
Surface Type					
Volume (BCM)					
Screen count (LPI)					
Diameter					
Condition					

D. Ink metering system

Doctor blade	Describe:

E. Ink pumping and mixing system

Type		Manufacturer	
Description			

F. Corona treater

Manufacturer		Model	
Maximum power output			

G. UV lamp(s)

Start time for lamp warm-up	
Stop time for lamp warm-up	
Energy consumption for UV lamp during warm-up	

H. Dimensions of …

… Dryers *(sketch)*		or	… UV lamps	
Interstation			Interstation	
Main			Main	

I. Blowers

Total number		Rated output	(cfm)
Location and size *(sketch)*			

J. Chillers

Total number		Location and size *(sketch)*	

K. VOC treatment

Type		Efficiency	

Observations:

II. Set-Up (Pre-Makeready)

A. Substrate: *(circle one)* PE PE/EVA OPP

Roll ID number		Manufacturer Name		Date of manufacture	

B. Ink: *(circle one)* Water UV Solvent

Ink manufacturer		Ink manufacturer on-site	

Record the ink components on the **Ink Set-up Sheet (Pre-Makeready)**

C. Plate

Material		Manufacturer	
Gauge		Plate-mounting method	

D. Observations:

III. Makeready

A. Substrate

Corona treatment specs			
Power = kW	Current = A	Voltage = V	Frequency = kHz

Surface Tension (dynes):

	Before corona treatment		After corona treatment	
Across Web	*Reading 1*	*Reading 2*	*Reading 1*	*Reading 2*
Left				
Right				

B. Record the ink compositions and adjustments on the **Ink Setup Sheet (Makeready)**.

C. Start

Start time	
Start footage (counter)	

D. Printing speed

Optimal printing speed obtained	

E. Stop

Stop time	
Stop footage (counter)	

F. Record the results of the ink densities on the **Density Sheet (Makeready)**.

G. Record the results of the tape-adhesiveness test on the **Tape-Adhesiveness Test Sheet.**

H. Record the results of the visual tests (mottle/lay, trap, dimensional stability, blocking) on the **Visual Quality Test Sheet.**

I. Observations:

IV. Running Parameters

A. Start

Start time	
Start footage (counter)	

B. At the beginning of the run, record the ink densities on the **Density Sheet**.

C. Record the ink viscosity on the **Running Viscosity Sheet** every 15 minutes during the run.

Observations:

D. Press speed

Press speed obtained	

Observations:

E. Dryers

	CI dryer #1	CI dryer #2	CI dryer #3	CI dryer #4	Main dryer
Temperature:					
Velocity:					
Area:					
Balance:					

Describe the number and type of adjacent presses. Note which were in operation during the performance demonstration and record the type of ink they were running:

F. Energy consumption

Measure and record energy consumption during the demonstration run

Printing press	
Ink pumps	
Corona treater	
Interstation UV lamp	
Final UV lamp	
Interstation dryer	
Final dryer	
Blowers	
Chillers	
VOC incinerators/ recovery units	

G. Ambient Conditions

Temperature	°F	Humidity	%

H. Stop

Stop time	
Stop footage (counter)	

I. Record the results of the ink densities on the **Density Sheet.**

J. Record the results of the tape-adhesiveness test on the **Tape-Adhesiveness Test Sheet.**

K. Record the results of the visual tests (mottle/lay, trap, dimensional stability, blocking) on the **Visual Quality Test Sheet.**

L. Waste substrate

Quantity generated during the 2-hr run (estimate)	

V. Clean-Up

A. Start time

Start time	

B. Cleaning chemical

Product name	Manufacturer	Type
1.		
2.		
3.		

C. Clean-up procedure

1.
2.
3.
4.
5.

D. Stop time

Stop time	

Ink Set-Up Sheet: REFLEX BLUE

Ink: *(circle)*	Water	UV	Solvent	-	PE	PE/EVA	OPP	Print Unit	

Pre-Makeready and Makeready

Ink	(lbs)	Manufacturer's number	
Water	(lbs)		
Extender	(lbs)	Manufacturer's number	
Solvent	(lbs)	Manufacturer's number	
Other additive:	(lbs)	Manufacturer's number	

During Run

Record when added…

Ink	(lbs)	Manufacturer's #		# impressions	
Water	(lbs)			# impressions	
Extender	(lbs)	Manufacturer's #		# impressions	
Solvent	(lbs)	Manufacturer's #		# impressions	
Other additive:	(lbs)	Manufacturer's #		# impressions	

Clean-Up

Ink remaining in bucket	(lbs)	Comments:			
Cleaning solutions added	(lbs)	Type		Manufacturer # (attach MSDS)	
	(lbs)	Type		Manufacturer # (attach MSDS)	
Ink scraped out	(lbs)	Comments:			
Ink wiped out	(lbs)	Dry rag weight	(lbs)	Rag weight after cleaning	(lbs)
Ink and cleaning solution removed	(lbs)	Comments:			

Calculate Total Ink Used

Calculate Ink Used	(lbs)	For how many substrates?	

Ink Set-Up Sheet: CYAN

Ink: *(circle)*	Water	UV	Solvent	-	PE	PE/EVA	OPP	Print Unit	

Pre-Makeready and Makeready

Ink	(lbs)	Manufacturer's number	
Water	(lbs)		
Extender	(lbs)	Manufacturer's number	
Solvent	(lbs)	Manufacturer's number	
Other additive:	(lbs)	Manufacturer's number	

During Run

Record when added…

Ink	(lbs)	Manufacturer's #		# impressions	
Water	(lbs)			# impressions	
Extender	(lbs)	Manufacturer's #		# impressions	
Solvent	(lbs)	Manufacturer's #		# impressions	
Other additive:	(lbs)	Manufacturer's #		# impressions	

Clean-Up

Ink remaining in bucket	(lbs)	Comments:			
Cleaning solutions added	(lbs)	Type		Manufacturer # (attach MSDS)	
	(lbs)	Type		Manufacturer # (attach MSDS)	
Ink scraped out	(lbs)	Comments:			
Ink wiped out	(lbs)	Dry rag weight	(lbs)	Rag weight after cleaning	(lbs)
Ink and cleaning solution removed	(lbs)	Comments:			

Calculate Total Ink Used

Calculate Ink Used	(lbs)	For how many substrates?	

Ink Set-Up Sheet: GREEN

Ink: *(circle)*	Water	UV	Solvent	-	PE	PE/EVA	OPP	Print Unit	

Pre-Makeready and Makeready

Ink	(lbs)	Manufacturer's number	
Water	(lbs)		
Extender	(lbs)	Manufacturer's number	
Solvent	(lbs)	Manufacturer's number	
Other additive:	(lbs)	Manufacturer's number	

During Run

Record when added…

Ink	(lbs)	Manufacturer's #		# impressions	
Water	(lbs)			# impressions	
Extender	(lbs)	Manufacturer's #		# impressions	
Solvent	(lbs)	Manufacturer's #		# impressions	
Other additive:	(lbs)	Manufacturer's #		# impressions	

Clean-Up

Ink remaining in bucket	(lbs)	Comments:			
Cleaning solutions added	(lbs)	Type		Manufacturer # (attach MSDS)	
	(lbs)	Type		Manufacturer # (attach MSDS)	
Ink scraped out	(lbs)	Comments:			
Ink wiped out	(lbs)	Dry rag weight	(lbs)	Rag weight after cleaning	(lbs)
Ink and cleaning solution removed	(lbs)	Comments:			

Calculate Total Ink Used

Calculate Ink Used	(lbs)	For how many substrates?	

Ink Set-Up Sheet: MAGENTA

Ink: *(circle)* | Water | UV | Solvent | - | PE | PE/EVA | OPP |

Print Unit	

Pre-Makeready and Makeready

Ink	(lbs)	Manufacturer's number	
Water	(lbs)		
Extender	(lbs)	Manufacturer's number	
Solvent	(lbs)	Manufacturer's number	
Other additive:	(lbs)	Manufacturer's number	

During Run

Record when added…

Ink	(lbs)	Manufacturer's #		# impressions	
Water	(lbs)			# impressions	
Extender	(lbs)	Manufacturer's #		# impressions	
Solvent	(lbs)	Manufacturer's #		# impressions	
Other additive:	(lbs)	Manufacturer's #		# impressions	

Clean-Up

Ink remaining in bucket	(lbs)	Comments:			
Cleaning solutions added	(lbs)	Type		Manufacturer # (attach MSDS)	
	(lbs)	Type		Manufacturer # (attach MSDS)	
Ink scraped out	(lbs)	Comments:			
Ink wiped out	(lbs)	Dry rag weight	(lbs)	Rag weight after cleaning	(lbs)
Ink and cleaning solution removed	(lbs)	Comments:			

Calculate Total Ink Used

Calculate Ink Used	(lbs)	For how many substrates?	

Ink Set-Up Sheet: WHITE

Ink: *(circle)* | Water | UV | Solvent | - | PE | PE/EVA | OPP |

Print Unit	

Pre-Makeready and Makeready

Ink	(lbs)	Manufacturer's number	
Water	(lbs)		
Extender	(lbs)	Manufacturer's number	
Solvent	(lbs)	Manufacturer's number	
Other additive:	(lbs)	Manufacturer's number	

During Run

Record when added…

Ink	(lbs)	Manufacturer's #		# impressions	
Water	(lbs)			# impressions	
Extender	(lbs)	Manufacturer's #		# impressions	
Solvent	(lbs)	Manufacturer's #		# impressions	
Other additive:	(lbs)	Manufacturer's #		# impressions	

Clean-Up

Ink remaining in bucket	(lbs)	Comments:			
Cleaning solutions added	(lbs)	Type		Manufacturer # (attach MSDS)	
	(lbs)	Type		Manufacturer # (attach MSDS)	
Ink scraped out	(lbs)	Comments:			
Ink wiped out	(lbs)	Dry rag weight	(lbs)	Rag weight after cleaning	(lbs)
Ink and cleaning solution removed	(lbs)	Comments:			

Calculate Total Ink Used

Calculate Ink Used	(lbs)	For how many substrates?	

Tape-Adhesiveness Test Sheet

Record after makeready and after print run.

Substrate: *(circle one)* PE PE/EVA OPP

End of makeready

	Pass	Fail	Comment
White Pull 1			
2			
Green Pull 1			
2			
Blue Pull 1			
2			
Magenta Pull 1			
2			
Cyan Pull 1			
2			

End of run

	Pass	Fail	Comment
White Pull 1			
2			
Green Pull 1			
2			
Blue Pull 1			
2			
Magenta Pull 1			
2			
Cyan Pull 1			
2			

Visual Quality Test Sheet

Record at end of makeready and end of print run.

Makeready

A. Mottle/Lay - visual quality:_____

_____

B. Trap:_____

_____

C. Dimensional Stability:_____

_____

D. Blocking:_____

_____

End of Run

A. Mottle/Lay:_____

_____

B. Trap:_____

_____

C. Dimensional Stability:_____

_____

D. Blocking:_____

_____

Density Sheet

Record at the end of the makeready and end of the print run.

End of Makeready:

	Green	Blue	Magenta	Cyan
Density 1				
Density 2				
Density 3				
Density 4				
Density 5				
Average Density				
Standard Deviation				

End of run:

	Green	Blue	Magenta	Cyan
Density 1				
Density 2				
Density 3				
Density 4				
Density 5				
Average Density				
Standard Deviation				

Observations:

Running Viscosity Sheet

Record every 15 minutes during the press run.

Ink: *(circle)* | Water | UV | Solvent | - | PE | PE/EVA | OPP |

REFLEX BLUE

Time	Start	15 min.	30 min.	45 min.	1 hour	1 hr. 15	1 hr. 30	1 hr. 45	2 hrs.
Viscosity									

CYAN

Time	Start	15 min.	30 min.	45 min.	1 hour	1 hr. 15	1 hr. 30	1 hr. 45	2 hrs.
Viscosity									

GREEN

Time	Start	15 min.	30 min.	45 min.	1 hour	1 hr. 15	1 hr. 30	1 hr. 45	2 hrs.
Viscosity									

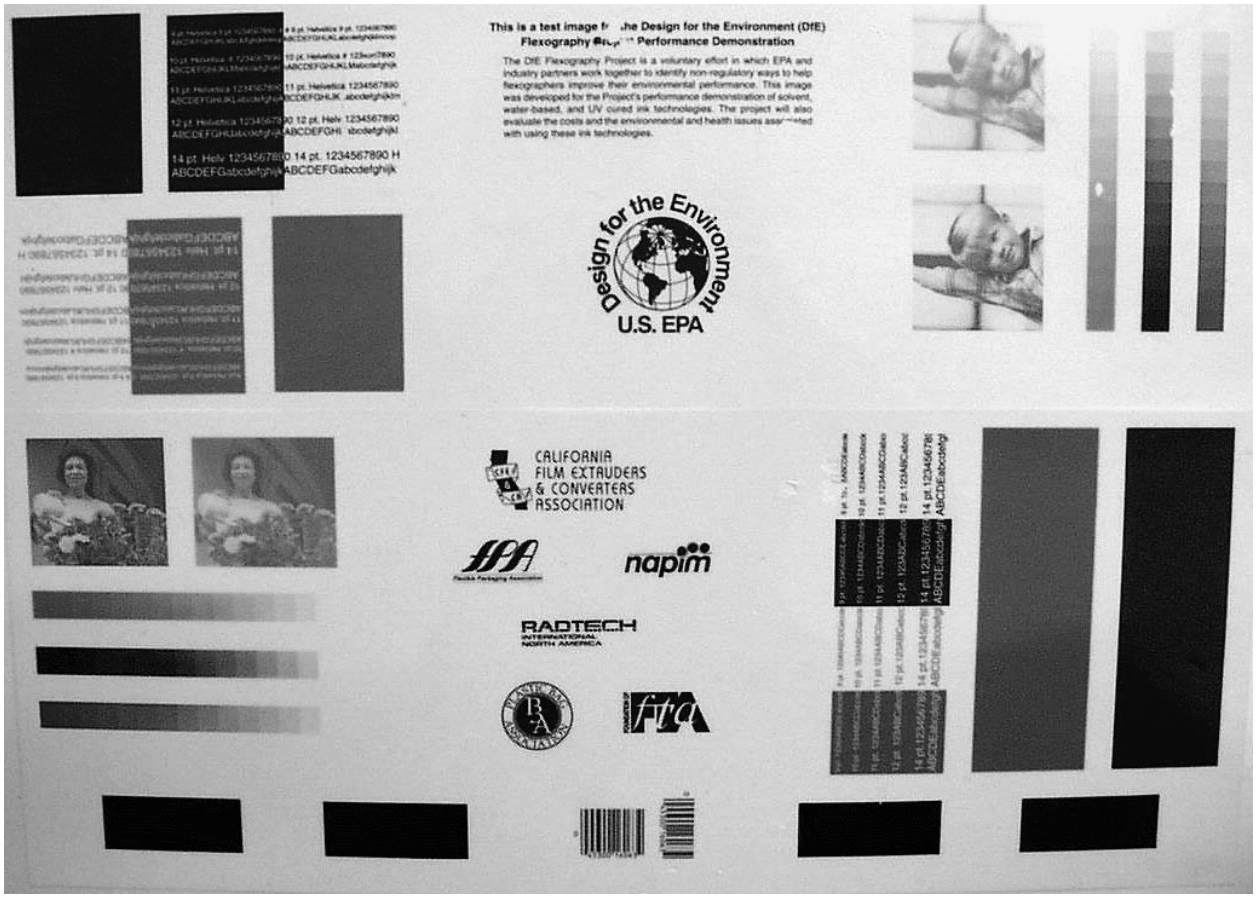
MAGENTA

Time	Start	15 min.	30 min.	45 min.	1 hour	1 hr. 15	1 hr. 30	1 hr. 45	2 hrs.
Viscosity									

WHITE

Time	Start	15 min.	30 min.	45 min.	1 hour	1 hr. 15	1 hr. 30	1 hr. 45	2 hrs.
Viscosity									

Appendix 4-D (Performance Chapter)
Test Image Design



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